AXBT Observations during Trident Warrior 2013

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Award Number: N0001413WX21237
http://www7320.nrlssc.navy.mil

LONG-TERM GOALS

Determine the impact of observations on the performance of ocean circulation forecast models and provide guidance on the design and implementation of ocean observing systems.

OBJECTIVES

The primary objective for the Trident Warrior 2013 Exercise is determining the impact of on scene data on the performance of forecast systems for prediction EM propagation characteristics. A number of supplemental projects were added for the exercise with a focus on air-sea interaction and shelf processes. However, the shelf circulation is impacted by Gulf Stream and slope circulation in this region. Additional airborne temperature profiles were obtained as part of this project to test the preformance of the forecast models in the region near the separation of the Gulf Stream from the coast at Cape Hatteras. The observations are used to evaluate a new vertical projection scheme, Improved Synthetic Ocean Profiles, and test a new hypothesis on conditional predictability of small scale frontogenesis with improved mesoscale prediction.

APPROACH

Airborne eXpendable BathyThermographs (AXBTs) were deployed on 4 flights of a Navy P-3 operated out of the Patuxent River Naval Air Station on a series of legs extending from the slope waters east of Norfolk, VA, crossing the Gulf Stream and into the warm Sargasso Sea water between July 11, 2013 (prior to the intensive field program of Trident Warrior 2013) and July 18, 2013 (the end of the intensive field program). The AXBT temperature profiles were processed in near real-time and transmitted to NAVO for assimilation into the real-time forecast model runs and used as validation data to evaluate forecast skill. Two of the aircraft tracks approximately underfly the Jason and AltiKa satellite altimeters. The temperature profiles along the altimeter tracks are used to evaluate the skill of a new vertical projection technique, Improved Synthetic Ocean Profiles (ISOP), used in the model data assimilation. The temperature profiles are used to test a new hypothesis about conditional predictability of frontogenesis (Jacobs et al. 2013).

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 2013		**00-00-2013 to 00-00-2013**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
AXBT Observations during Trident Warrior 2013	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Research Laboratory,Oceanography Division, Code 7323,Stennis Space Center,MS,39529**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**4**	

The key individuals involved in this work are"

--James G. Richman, NRL, PI of this grant: Richman participated in the collection of the AXBT data and insertion of the data into the Navy real-time data queue. He has performed the initial quality control on the data and will be responsible for the frontogenesis hypothesis testing. He will lead an additional task to characterize the life history of a warm core ring found in the data, which has been cooled from 18C to 15C over its life.

--Gregg A. Jacobs, NRL: Jacobs will lead the forecast skill evaluation for the 6 real-time model suite and the hindcast model evaluation.

--Jeffrey Kerling, NAVO: Kerling rescued the surplus AXBTs used in this project and directed the work to equip the P-3 with data acquistion systems. Kerling performed the real-time data quality assurance and prepare the data files for transmission to the Navy real-time data queue for assimilation into the real-time models.

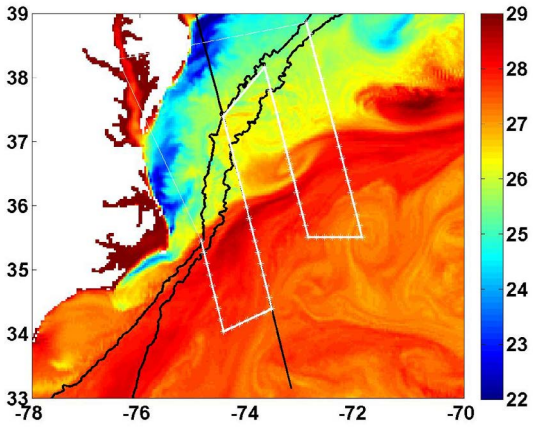
--Robert Liang, NRL: Liang operated the AIRDALE LT data acquisition system on the flights.

--Jaime Pupek, PAX: Pupek operated the LCAP data acuqisition system on the flights.

WORK COMPLETED

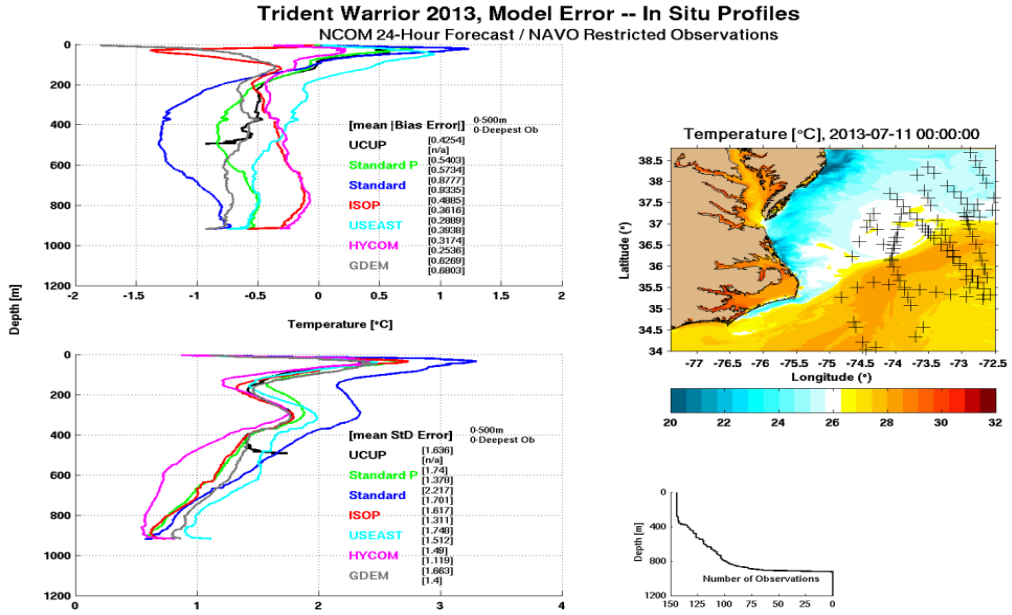
262 AXBTs were deployed 4 flights of a Navy P-3 operated out of the Patuxent River Naval Air Station on a series of legs extending from the slope waters east of Norfolk, VA, crossing the Gulf Stream and into the warm Sargasso Sea water between July 11, 2013 (prior to the intensive field program of Trident Warrior 2013) and July 18, 2013 (the end of the intensive field program). The AXBT temperature profiles were processed in near real-time and transmitted to NAVO for assimilation into the real-time forecast model runs and used as validation data to evaluate forecast skill. Two of the aircraft tracks approximately underfly the Jason and AltiKa satellite altimeters. The temperature profiles along the altimeter tracks are used to evaluate the skill of a new vertical projection technique, Improved Synthetic Ocean Profiles (ISOP), used in the model data assimilation. The temperature profiles are used to test a new hypothesis about conditional predictability of frontogenesis (Jacobs et al. 2013).

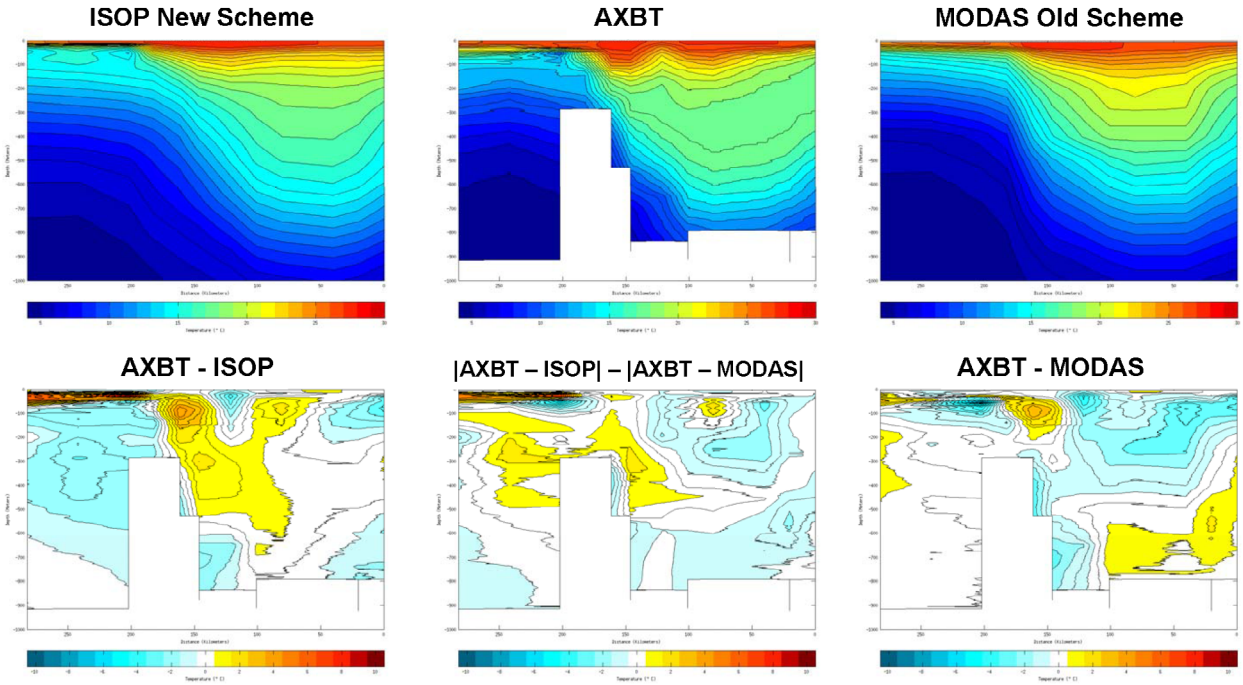
RESULTS



The AXBTs were deployed approximately every 16 km along a series of leg extending from the slope water across the Gulf Stream into the Sargasso Sea, similar to the pattern for July 11, 2013. On July 11, one leg followed a track of the AltiKa satellite altimeter. On the last flight on July 18, one leg followed a track of the Jason-2 altimeter. The data were processed withing 3 hours of the landing of the aircraft and JJXX messages were emailed to the Naval Oceanographic Office (NAVO) for inclusion in the real-time data assimilation stream for the global ocean forecast model (HYCOM) and regional East Coast model (USEast) run by NAVO and a series of real-time model, Undersea Common Uncertainty Principle (UCUP) ensemble, RELO

assimilating satellite data only (Standard), RELO assimilating satellite and profile data (StandardPlus) and RELO assimilating altimetry data with a new vertical correlation profile (ISOP). The AXBT profile data are compared to the 24 hour forecasts. Surprisingly, the global model and the new ISOP vertical correlation technique performed the best and the satellite only Standard version of RELO performed the worst. The AXBTs were assimilated into all models except the Standard model. Thus the high resolution AXBT data had a significan impact on the model Gulf Stream forecasts.





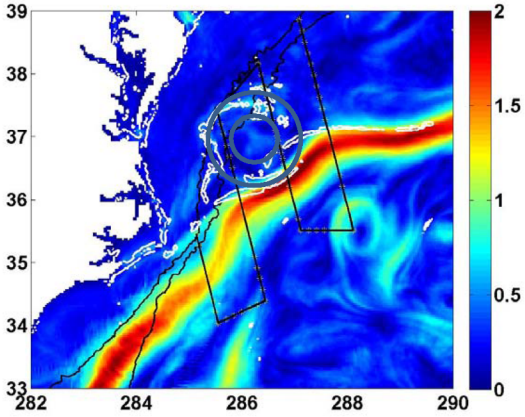
Blue: AXBT cooler than ISOP
Orange: AXBT warmer than ISOP

Blue: ISOP closer to AXBT
Orange: MODAS closer to AXBT

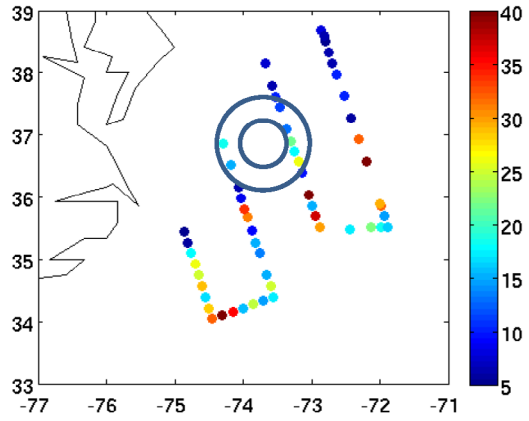
Blue: AXBT cooler than ISOP
Orange: AXBT warmer than ISOP

The AXBT data are compared to the synthetic profiles of temperature obtained from the sea surface height via the current MODAS scheme and the new Improved Synthetic Ocean Profiles. As noted earlier, the ISOP model performed better than all the other regional models. Direct comparison of the profiles, seen above, show that the new profile scheme is closer to the AXBT observations except in the mixed layer in the slope water and the northern edge of the Gulf Stream.

In a recent paper, Jacobs et al (2013), we show that straining of buoyancy gradients by the large and mesoscale flow can generate ageostrophic secondary flows which lead to thin mixed layer filaments.



Surface speed from the model on July 11 with Omega vector contours



Mixed layer depth from AXBT profiles and location of warm core ring

In the figure above, the left had panel shows surface speed from the model with the AXBT flight path overlaid and contours of large frontogenesis. In the model the currents from an old warm core ring lead to enhanced frontogenesis. In the right hand panel the mixed layer depths obtain from the AXBT profiles are shown along the flight path. The old warm core ring is located at the northern edge of the middle legs. The mixed layer depths are smaller where the frontogenesis is large. In the paper, we showed that increasing the skill of the mesoscale forecast improved the skill in the mixed layer depth and vertical velocity. The AXBTs provided much higher resolution temperature profiles than typically available with at a quick look improved skill in the mixed layer depth.

IMPACT/APPLICATIONS

The mixed layer depth and upper ocean temperature strongly affect the propagation of sound. The AXBT observations appear to validate a new hypothesis about the conditional predictability of small scale features in the ocean which should lead to better predictions of the acoustic environment.

REFERENCES

Jacobs, G. A., J. G. Richman, J. D. Doyle,, P. Spence, B. Bartels, C. N. Barron, R. Helber and F Bub (2013), Conditional deterministic predictability of submesoscale frontogenesis in the ocean, Ocean Modelling, under revision.